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IN Notomi, Kanji; Tomita, Kazuyuki; Hosokawa, Hiroshi; Takemoto, Masayuki
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AB The **Fe** alloy contains **Cr** 20-35, **Al** 4-12, O .ltoreq.0.10, and N 0.05-0.20 wt.%. The **Fe** alloy may further contain (1) 0.001-0.1 wt.% (solid. soln. limit) or 0.1-1 wt.% Y, Hf, Sc, and/or rare earth and/or (2) .ltoreq.1 wt.% **Zr**, Nb, and/or **Ti**. The alloy is useful for heaters, high temp. parts, etc.

PATENT ABSTRACTS OF JAPAN

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(54) FE-CR-AL POWDER ALLOY

(57)Abstract:

PURPOSE: To obtain an Fe-Cr-Al powder alloy free from the fear of the generation of sagging caused by creep deformation at a high temp. and excellent in oxidation resistance by specifying the content of Cr an Al and prescribing the content of O and N.

CONSTITUTION: The Fe-Cr-Al powder alloy contg., by weight, 20 to 35% Cr, 4 to 12% Al, ≤0.10% O and 0.05 to 0.20% H, furthermore contg., at need, 0.001% to solid soln. limit (≤0.1%) of or 0.1 to 1% of one or more kinds among Y, Hf, Sc and rare earth elements and/or ≤1% of one or more kinds among Zr, Nb and and the balance Fe with inevitable impurities is suitable for a heater material or the like. Even if the alloy i used at a high temp. for a long time, there is no fear of the generation of sagging caused by creep deformation, and its oxidation resistance can moreover be improved according to necessary.

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* NOTICES *

1. This document has been translated by computer.So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1] Cr 20 - 35wt%, aluminum 4 - 12wt%, oxygen Less than [0.10wt%], nitrogen Fe-Cr-aluminum system powder alloy which contains 0.05 - 0.20wt% and is characterized by the bird clapper from a remainder unescapable impurity and Fe.
[Claim 2] Cr 20 - 35wt%, aluminum 4 - 12wt%, oxygen Less than [0.10wt%], nitrogen Fe-Cr-aluminum system powder alloy which contains 0.05 - 0.20wt%, contains more than 0.001wt% and below a solid-solution limit (less tha [0.1wt%]) for one or more sorts chosen from Y, Hf, Sc, and rare earth elements in total further, and is characterized the bird clapper from a remainder unescapable impurity and Fe.
[Claim 3] Cr 20 - 35wt%, aluminum 4-12wt% oxygen Less than [0.10wt%], nitrogen Fe-Cr-aluminum system pow alloy which contains 0.05 - 0.20wt%, contains less than [1wt%] and more than 0.1wt% for one or more sorts chosen from Y, Hf, Sc, and rare earth elements in total further, and is characterized by the bird clapper from a remainder unescapable impurity and Fe.
[Claim 4] Cr 20 - 35wt%, aluminum 4-12wt% oxygen Less than [0.10wt%], nitrogen Fe-Cr-aluminum system pow alloy which contains 0.05 - 0.20wt%, contains less than [1wt%] for one or more sorts chosen from Zr, Nb, and Ti in total further, and is characterized by the bird clapper from a remainder unescapable impurity and Fe.
[Claim 5] Cr 20 - 35wt%, aluminum 4-12wt% oxygen Less than [0.10wt%], Nitrogen 0.05 - 0.20wt% is contained. further Y, Hf, Sc, The Fe-Cr-aluminum system powder alloy which contains less than [1wt%] for one or more sorts which contained less than [1wt%] and more than 0.1wt% in total, and chose one or more sorts chosen from rare ear elements from Zr, Nb, and Ti in total, and is characterized by the bird clapper from a remainder unescapable impurit and Fe.
[Claim 6] Cr 20 - 35wt%, aluminum 4 - 12wt%, oxygen Less than [0.10wt%], Nitrogen 0.05 - 0.20wt% is containe further Y, Hf, Sc, In total one or more sorts chosen from rare earth elements More than 0.001wt% The Fe-Cr-alumin system powder alloy which contains less than [1wt%] in the one or more sort sum total which contained below the solid-solution limit (less than [0.1wt%]), and was chosen from Zr, Nb, and Ti, and is characterized by the bird clapp from a remainder unescapable impurity and Fe.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] this invention -- an Fe-Cr-aluminum system powder alloy -- being related -- further -- detaile - a heater and a high temperature service -- it is related with the suitable Fe-Cr-aluminum system powder alloy for a member etc.
[0002]
[Description of the Prior Art] Before, the Fe-Cr-aluminum system alloy has been used very effectively as electrical resistance materials, such as industrial furnaces. And after casting, hot rolling and cold rolling, and a wire drawing ar performed, and this Fe-Cr-aluminum system alloy is manufactured, after usually dissolving in atmosphere, such as a vacuum. However, toughness was inferior in the Fe-Cr-aluminum system alloy manufactured by the solution process and it was difficult to process it into a board, a line, or a band.
[0003] Therefore, in the former, manufacturing an Fe-Cr-aluminum system alloy from powder to JP,62-280348,A is proposed, and it is compensating the fault of the Fe-Cr-aluminum system alloy manufactured by the solution process
[0004] And although this Fe-Cr-aluminum system alloy sintered compact is carried out if a crack does not occur by indicating that it is less than [oxygen 0.02wt%] and less than [nitrogen 0.03wt%], and limiting oxygen and nitroge in this way however, in the heater material which consists of this Fe-Cr-aluminum system alloy sintered compact If i used for the elevated temperature of 1200-1500 degrees C for a long time, in case an exoergic furnace will be design as well as a sagging phenomenon occurring notably and producing degradation of a heater by creep deformation, generating of sagging will be expected and designed and there is a problem of barring miniaturization of an exoergic furnace.
[0005] Moreover, making an Fe-Cr-aluminum system powder alloy contain the rare earth elements not more than 1w in JP,02-205659,A, and improving the processability of a powder alloy greatly to it is proposed.
[0006]
[Problem(s) to be Solved by the Invention] As a result of this invention person's inquiring wholeheartedly and repeat examination in view of the various troubles of the Fe-Cr-aluminum system alloy in the former explained above, even it used this invention in the elevated temperature for a long time, it does not have fear of sagging generating by creep deformation, and developed the Fe-Cr-aluminum system powder alloy suitable as heater material and a high-temperature-service member.
[0007]
[Means for Solving the Problem] The Fe-Cr-aluminum system powder alloy concerning this invention Cr 20 - 35wt% aluminum 4 - 12wt%, oxygen Less than [0.10wt%], Nitrogen Contain 0.05 - 0.20wt% and the Fe-Cr-aluminum system powder alloy characterized by the bird clapper from a remainder unescapable impurity and Fe is considered a the 1st invention. Cr 20 - 35wt%, aluminum 4 - 12wt%, oxygen Less than [0.10wt%], Nitrogen 0.05 - 0.20wt% is contained. further Y, Hf, Sc, In total one or more sorts chosen from rare earth elements More than 0.001wt% Contain below a solid-solution limit (less than [0.1wt%]), and the Fe-Cr-aluminum system powder alloy characterized by th bird clapper from a remainder unescapable impurity and Fe is considered as the 2nd invention. Cr 20 - 35wt%, aluminum 4-12wt% oxygen Less than [0.10wt%], Nitrogen 0.05 - 0.20wt% is contained. further Y, Hf, Sc, Less tha [1wt%] and more than 0.1wt% are contained for one or more sorts chosen from rare earth elements in total. The Fe-Cr-aluminum system powder alloy characterized by the bird clapper from a remainder unescapable impurity and Fe i considered as the 3rd invention. Cr 20 - 35wt%, aluminum 4-12wt% oxygen Less than [0.10wt%], Nitrogen 0.05 - 0.20wt% is contained. further Zr, Nb, Contain less than [1wt%] for one or more sorts chosen from Ti in total, and th

Fe-Cr-aluminum system powder alloy characterized by the bird clapper from a remainder unescapable impurity and is considered as the 4th invention. Cr 20 - 35wt%, aluminum 4-12wt% oxygen Less than [0.10wt%], Nitrogen 0.05 0.20wt% is contained. further Y, Hf, Sc, Less than [1wt%] and more than 0.1wt% are contained for one or more sor chosen from rare earth elements in total. Moreover, less than [1wt%] is contained for one or more sorts chosen from Zr, Nb, and Ti in total. The Fe-Cr-aluminum system powder alloy characterized by the bird clapper from a remainde unescapable impurity and Fe is considered as the 5th invention. Cr 20 - 35wt%, aluminum 4 - 12wt%, oxygen Less than [0.10wt%], Nitrogen 0.05 - 0.20wt% is contained. further Y, Hf, Sc, In total one or more sorts chosen from rar earth elements More than 0.001wt% Less than [1wt%] is contained in the one or more sort sum total which contain below the solid-solution limit (less than [0.1wt%]), and was chosen from Zr, Nb, and Ti, and it consists of six invention which considers the Fe-Cr-aluminum system powder alloy characterized by the bird clapper from a remainder unescapable impurity and Fe as the 6th invention.

[0008] The Fe-Cr-aluminum system powder alloy concerning this invention is explained to a detail below. First, the component and component rate of an Fe-Cr-aluminum system powder alloy concerning this invention are explained.

[0009] Cr is an element which gives oxidation resistance, and if less than [20wt%] is [a content] inadequate as for oxidation resistance and it exceeds 35wt% less than, it forms and stiffens a sigma phase. Therefore, Cr content may b 20 - 35wt%.

[0010] aluminum is an element which gives oxidation resistance like Cr, and less than [4wt%], if a content runs sho of oxidation resistance and exceeds 12wt%, it stiffens it. Therefore, aluminum content may be 4 - 12wt%.

[0011] Processability will become bad if an oxygen content exceeds 0.10wt(s)%. Therefore, an oxygen content is ma into less than [0.10wt%].

[0012] If sagging-proof nature gets worse less than [0.05wt%] and a nitrogen content exceeds 0.20wt%, processabi will deteriorate. Therefore, a nitrogen content may be 0.05 - 0.20wt%.

[0013] a heater and a high temperature service -- in order to enable it to use a member etc. at an elevated temperature for a long time, and it is important to suppress the generation rate of the oxide film of aluminum and Cr and to suppr the generation rate of an oxide film, it is good to raise the peeling resistance of an oxide film, for that, it is the sum to about one or more sorts chosen from Y, Hf, Sc, and rare earth elements, such as Ce, La, Pr, and Nd, and it is good to make a content into less than [1wt%]

[0014] Moreover, Y, Hf, Sc, Ce, La, Pr, Nd, etc. make high the degree which an oxide film sticks on an alloy, and ha the effect which prevents an oxide film's exfoliating and the amount of oxides increasing. However, since toughness will deteriorate and sagging will become large if a content exceeds 1wt% also for one sort or the sum total, one or m sorts of contents chosen from rare earth elements, such as Y, Hf, Sc, or Ce, La, Pr, Nd, are made into less than [1wt% in total.

[0015] Furthermore, since Y, Hf, Sc, and rare earth elements strengthen adhesion of the 2Oaluminum3 coat and alloy which are formed in the front face of an Fe-Cr-aluminum system alloy, although they are effective in improving life properties, such as oxidation resistance and oxide-skin adhesion A content cannot acquire oxidation resistance good less than [0.001wt%]. Moreover, if a content exceeds a solid-solution limit (0.1wt%), the crystallization object of a active element will come to appear, a secondary recrystallizing temperature becomes high, sagging-proof nature com to deteriorate conversely, and there is a problem for the use as which this property is required. Therefore, although th minimum of one or more sorts of contents chosen from Y, Hf, Sc, and rare earth elements carries out to more than 0.001wt% in total, for the use as which especially the above-mentioned sagging-proof nature is required, it is desirab to carry out to below a solid-solution limit (0.1wt%).

[0016] a heater and a high temperature service, in order to enable it to use a member etc. at an elevated temperature f a long time In order it is important to suppress the generation rate of the oxide film of aluminum and Cr and to suppr the generation rate of an oxide film It is good to raise the peeling resistance of an oxide film. for that It is what make content less than [1wt%] for one or more sorts chosen from Zr, Nb, and Ti in total. It is good to make one or more sorts chosen from these contain. Zr, Nb, by making high the degree which an oxide film sticks on an alloy, and havin the effect which prevents an oxide film's exfoliating and the amount of oxides increasing, if a content exceeds 1wt% also in one sort or the sum total, toughness will deteriorate, and sagging comes for Ti etc. to be large Therefore, one more sorts of contents chosen from Zr, Nb, and Ti may be less than [1wt%] in total.

[0017] In the Fe-Cr-aluminum system powder alloy concerning this invention, AlN was formed by aluminum and N majority of these AlN(s) are distributed minutely uniformly, and the temperature of 1100-1200 degrees C has preven the grain growth. Moreover, if the Fe-Cr-aluminum system powder alloy concerning this invention is made to contai

which element of Zr, Nb, and Ti, it will be distributed still more minutely uniformly and a grain growth will be prevented from the AlN particle which ZrN, NbN, TiN, etc. explained above by Zr, Nb, Ti, and N by the complex grain-growth prevention effect of the above-mentioned AlN particle and which particle of ZrN, NbN, and TiN also i the temperature of nearly 1200 degrees C. since it is the 1200-degree C neighborhood and an elevated temperature, t crystal-growth force is large, it becomes a macro-crystal grain, therefore a creep property is improved, and generatin of sagging becomes and although the grain-growth prevention effect decreases and secondary recrystallization happe by coalesce or dissolution of AlN, ZrN, NbN, TiN, etc. in this temperature neighborhood, there is less at the time of use [little]

[0018] On the other hand, in the Fe-Cr-aluminum system alloy by the conventional ingoting method, since there is n particle which prevents a grain growth, although a gently-sloping grain growth starts gradually in connection with a temperature rise, a macro-crystal grain is not produced after the recrystallization in the temperature of 600-700 degre C.

[0019]

[The example of fruit **] The example of the Fe-Cr-aluminum system powder alloy concerning this invention is explained.

[0020]

[Example of fruit ** 1] The alloy-powder end of the component and component rate which are shown in Table 1 wa manufactured by the atomizing method. In addition, No.1-No.3 (comparison material) were manufactured by the arg atomizing method, and No.4-No.13 (this invention) were manufactured by the nitrogen gas atomizing method. No.14 are based on the ingoting method used for comparison, and are JIS FCH1 steel.

[0021] Bore 70phi and the container made from mild steel with a length of 150mm were filled up with these powder No.1-No.13, and they were sealed after after [vacuum heating] deaeration. Then, in the temperature of 1100 degree C, it extruded to the bar of 30 phixL after 2-hour heating, and the powder material of true density (100% density) wa created.

[0022] From No.14 of 13 kinds of this powder material, and the ingot material for comparison, it considered as the diameter of 8mm by the wire drawing after hot rolling, and the 8phix200mm sagging test piece was created. The sagging examination installed the test piece 2 on the fixture 1 whose span distance as shown in drawing 1 is 140mm, heated it in temperature of 1500 degrees C for 5 hours, and was performed by measuring the amount of displacemen A center sections of the test piece 2. The test result is shown in Table 2. It turns out that the Fe-Cr-aluminum system powder alloy which requires N content for a 0.05 - 0.20wt% this invention from this table 2 is extremely excellent in sagging-proof nature. moreover, comparison material -- No.1-No.3 have a sagging ** case according to manufacture conditions and a test condition still more greatly than the ingot material of No.14, and they are not practical

[0023] Although the microphotography of the crystalline structure of the cross section of the sagging examination w rod after 5-hour heating is shown in the temperature of 1500 degrees C at drawing 2 and drawing 3 , the comparison material of No.1 of drawing 2 is an organization where the sagging property has deteriorated, and a macro-crystal gr is not accepted. On the other hand, a macro-crystal grain is accepted in No.4 of the Fe-Cr-aluminum system powder alloy concerning this invention of drawing 3 , therefore creep resistance improves, and the property which was excellent in the sagging examination is shown.

[0024] Next, in order to investigate the life property of the material shown in Table 1, heating wire of JIS C2524 (19 and life test of a band were performed. For 2 minutes, this examination repeats operation of the pause during energization and 2 minutes, performs a test piece 2 so that the test piece 2 used as the 0.5phix200mm wire rod may b fixed to the supported-end child 4 at U typeface as shown in drawing 4 , and the position of the bottom 3 of the test piece 2 of U typeface may become the temperature which is 1300 degrees C, and it asks for the number of times of energization when a test piece 2 is disconnected.

[0025] 100 times or more of the number of times of energization is required for the convention life value of the charg of an Fe-Cr-aluminum system powder alloy which carries out a deer and a heater life value requires for this inventio according to the alloyed wire for electric heat and band of JIS C2520 (1986). The result of life test is shown in Table with the sagging test result.

[0026] As shown in Table 2, they are less than [oxygen 0.10wt%] and nitrogen 0.05-0.20. Into a wt% Fe-Cr-aluminum system powder alloy One or more sorts of sum total contents of rare earth elements, such as Zr, Nb, Ti, Y Hf, Sc, and Ce, La, Pr, Nd, are less than [1wt%]. It turns out that the life value of heater material which consists of charge of an Fe-Cr-aluminum system powder alloy concerning this invention is improving more sharply than JIS FC

of ingot material, and it also doubles and has long lasting nature with hot sagging-proof nature.

[0027]

[Table 1]

No	化学成分（wt%）														
	C	Cr	Al	Zr	Nb	Ti	Y	Hf	Ce	La	Pr	Nd	O	N	Fe
1	0.01	23	5.1	—	—	—	—	—	—	—	—	—	0.015	0.009	残部
2	0.01	27	5.3	—	—	—	—	—	—	—	—	—	0.012	0.011	〃
3	0.09	20	5.2	—	—	—	—	—	—	—	—	—	0.015	0.013	〃
4	0.01	23	5.2	—	—	—	—	—	—	—	—	—	0.015	0.060	〃
5	0.01	27	5.4	—	—	—	—	—	—	—	—	—	0.010	0.080	〃
6	0.07	21	10.2	—	—	—	—	—	—	—	—	—	0.013	0.190	〃
7	0.01	23	5.0	0.2	0.1	—	—	—	—	—	—	—	0.011	0.075	〃
8	0.03	21	5.3	0.3	0.1	0.1	—	—	—	—	—	—	0.030	0.070	〃
9	0.02	23	5.9	0.2	—	—	0.7	—	—	—	—	—	0.010	0.105	〃
10	0.01	27	5.1	0.1	—	—	—	0.4	—	—	—	—	0.014	0.083	〃
11	0.01	23	7.0	—	—	—	—	—	0.4	0.2	0.1	0.1	0.070	0.140	〃
12	0.01	23	5.7	0.3	—	0.2	0.1	—	0.2	—	—	—	0.035	0.071	〃
13	0.02	20	5.2	0.2	—	0.1	—	0.2	0.1	0.1	—	—	0.047	0.095	〃
14	0.02	23	5.4	—	—	—	—	—	—	—	—	—	0.006	0.020	〃

No.1～No.3・・・比較材，No.4～No.13・・・本発明，No.14・・・溶製材

[0028]

[Table 2]

No	高温ダレ量 (mm)	寿命値 (回)
1	32.5	218
2	28.1	242
3	29.3	210
4	2.5	230
5	2.0	283
6	2.5	329
7	0.4	324
8	3.3	390
9	7.2	513
10	6.0	472
11	6.5	501
12	8.0	522
13	8.0	487
14	31.5	223

No.1～No.3・・・比較材

No.4～No.13・・本発明

No.14・・・溶製材

[0029]
[Example of fruit ** 2] this example -- setting -- Y, Hf, Sc, and rare earth elements -- 0.001 - 0.1wt% -- a predominance over the sagging-proof nature in the case of containing is explained below The alloy-powder end of th component and component rate which are shown in Table 3 was manufactured by the atomizing method. In addition the alloy which corresponds to a claim 1 by the case where No.15-No.18 (this invention material 1) do not contain Y Hf, Sc, and rare earth elements, and No.19-No.22 (this invention material 2) are alloys which correspond to a claim 3 by the case where it contains more than a solid-solution limit (0.1wt%), and explain Y, Hf, Sc, and rare earth elemen for comparison. No.23-No.28 (this invention material 3) -- Y, Hf, Sc, and rare earth elements -- more than 0.001wt% the case of the alloy which contains and corresponds to a claim 2 by the below solid-solution limit (0.1wt%) case is shown [0030] Bore 70phi and the container made from mild steel with a length of 150mm were filled up with these powder, and it was sealed after after [vacuum heating] deaeration. Then, in the temperature of 1100 degrees C, it extruded to the bar of 30 phixL after 2-hour heating, and the powder material of true density (100% density) was created. 14 kinds of this powder material was made into the diameter of 8mm by the wire drawing after hot rolling, a the 8phix200mm sagging test piece was created.
[0031] The sagging examination installed the test piece 2 on the fixture 1 whose span distance as shown in drawing 1 140mm, heated it in temperature of 1500 degrees C for 5 hours, and was performed by measuring the amount of displacement of A center sections of the test piece 2. The test result is shown in Table 4.
[0032] Next, in order to investigate the life property of the material shown in Table 1, heating wire of JIS C2524 (19 and life test of a band were performed. For 2 minutes, this examination repeats operation of the pause during energization and 2 minutes, performs a test piece 2 so that the test piece 2 used as the 0.5phix200mm wire rod may b fixed to the supported-end child 4 at U typeface as shown in drawing 4 , and the position of the bottom 3 of the test piece 2 of U typeface may become the temperature which is 1300 degrees C, and it asks for the number of times of energization when a test piece 2 is disconnected.
[0033] 100 times or more of the number of times of energization is required for the convention life value of the charg of an Fe-Cr-aluminum system powder alloy which carries out a deer and a heater life value requires for this inventio according to the alloyed wire for electric heat and band of JIS C2520 (1986). The result of life test is shown in Table

with the sagging test result.
[0034] Although sagging-proof nature is good in the powder heater material (this invention material 1) which does n contain one or more sorts chosen from rare earth elements, such as Y, Hf, Sc, and Ce, La, Pr, Nd, as shown in Table and 4, it turns out that a life value is low. moreover, one or more sorts chosen from rare earth elements, such as Y, H Sc, and Ce, La, Pr, Nd, -- the sum total -- 0.3 - 0.8wt% -- in the heater material (this invention material 2) to contain, although the life property is good, it turns out that sagging-proof nature has deteriorated compared with the comparis material 1 And one or more sorts chosen from rare earth elements, such as this invention material 3 applicable to a claim 3, i.e., Y, Hf, and Sc, and Ce, La, Pr, Nd, are known by that both the heater material that is below solid-solutio limits (0.1wt%) is excellent in sagging-proof nature and a life property in total more than at 0.001wt%.
[0035]
[Table 3]

[0036]
[Table 4]

No	化学成分 (wt%)														
	C	Cr	Al	Zr	Nb	Ti	Y	Hf	Ce	La	Pr	Nd	O	N	Fe
15	0.01	23	5.2	−	−	−	−	−	−	−	−	−	0.015	0.060	残部
16	0.01	27	5.4	−	−	−	−	−	−	−	−	−	0.010	0.080	〃
17	0.01	23	5.0	0.2	0.1	−	−	−	−	−	−	−	0.011	0.075	〃
18	0.03	21	5.3	0.3	0.1	0.1	−	−	−	−	−	−	0.030	0.070	〃
19	0.02	23	5.9	0.2	−	−	0.7	−	−	−	−	−	0.010	0.105	〃
20	0.01	27	5.1	0.1	−	−	−	0.4	−	−	−	−	0.014	0.083	〃
21	0.01	23	7.0	−	−	−	−	−	0.4	0.2	0.1	0.1	0.070	0.140	〃
22	0.01	23	5.7	0.3	−	0.2	0.1	−	0.2	−	−	−	0.035	0.071	〃
23	0.02	23	5.3	0.2	−	−	0.01	−	−	−	−	−	0.020	0.090	〃
24	0.01	27	5.8	0.2	−	−	0.005	−	−	−	−	−	0.025	0.085	〃
25	0.03	23	6.0	0.2	0.1	0.1	0.002	−	0.002	−	−	−	0.015	0.120	〃
26	0.01	27	5.2	−	−	0.1	−	0.05	−	−	−	−	0.020	0.105	〃
27	0.02	23	7.0	0.2	−	−	−	0.02	0.02	−	−	−	0.010	0.095	〃
28	0.02	23	5.4	0.3	−	−	−	−	0.02	0.02	0.01	−	0.015	0.088	〃

No.15～No.18（本発明材1），No.19～No.22（本発明材2），
No.23～No.28（本発明材3）

No	高温ダレ量 (mm)	寿命値 (回)
15	2.5	230
16	2.0	283
17	0.4	324
18	3.3	390
19	7.2	513
20	6.0	472
21	6.5	501
22	8.0	522
23	2.2	515
24	2.8	490
25	3.2	480
26	1.5	520
27	2.6	462
28	1.4	494

No.15～No.18（本発明材1）

No.19～No.22（本発明材2）

No.23～No.28（本発明材3）

[Effect of the Invention] As explained above, since the Fe-Cr-aluminum system powder alloy concerning this invent is the above-mentioned composition By considering as less than [oxygen content 0.10wt%], nitrogen-content 0.05 - 0.20wt%, and making one or more sorts chosen from Y, Hf, Sc, rare earth elements, and Zr, Nb and Ti contain furthe In the elevated temperature of 1200-1500 degrees C, it excels in sagging-proof nature and oxidation resistance extremely, and it is a material suitable as a heater and a high-temperature-service member, and the contribution on industry is very large.

[Translation done.]

* NOTICES *

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TECHNICAL FIELD

[Industrial Application] this invention -- an Fe-Cr-aluminum system powder alloy -- being related -- further -- detaile - a heater and a high temperature service -- it is related with the suitable Fe-Cr-aluminum system powder alloy for a member etc.

[Translation done.]

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PRIOR ART

[Description of the Prior Art] Before, the Fe-Cr-aluminum system alloy has been used very effectively as electrical resistance materials, such as industrial furnaces. And after casting, hot rolling and cold rolling, and a wire drawing ar performed, and this Fe-Cr-aluminum system alloy is manufactured, after usually dissolving in atmosphere, such as a vacuum. However, toughness was inferior in the Fe-Cr-aluminum system alloy manufactured by the solution process and it was difficult to process it into a board, a line, or a band.

[0003] Therefore, in the former, manufacturing an Fe-Cr-aluminum system alloy from powder to JP,62-280348,A is proposed, and it is compensating the fault of the Fe-Cr-aluminum system alloy manufactured by the solution process

[0004] And it is indicated that this Fe-Cr-aluminum system alloy sintered compact is less than [oxygen 0.02wt%] a less than [nitrogen 0.03wt%]. Thus, although it is carrying out if a crack does not occur by limiting oxygen and nitrogen however, in the heater material which consists of this Fe-Cr-aluminum system alloy sintered compact If it is used for the elevated temperature of 1200-1500 degrees C for a long time, in case an exoergic furnace will be design as well as a sagging phenomenon occurring notably and producing degradation of a heater by creep deformation, generating of sagging will be expected and designed and there is a problem of barring miniaturization of an exoergic furnace.

[0005] Moreover, making an Fe-Cr-aluminum system powder alloy contain the rare earth elements not more than 1w in JP,02-205659,A, and improving the processability of a powder alloy greatly to it is proposed.

[Translation done.]

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EFFECT OF THE INVENTION

[Effect of the Invention] As explained above, since the Fe-Cr-aluminum system powder alloy concerning this invent is the above-mentioned composition By considering as less than [oxygen content 0.10wt%], nitrogen-content 0.05 - 0.20wt%, and making one or more sorts chosen from Y, Hf, Sc, rare earth elements, and Zr, Nb and Ti contain furthe In the elevated temperature of 1200-1500 degrees C, it excels in sagging-proof nature and oxidation resistance extremely, and it is a material suitable as a heater and a high-temperature-service member, and the contribution on industry is very large. It is.

[Translation done.]

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TECHNICAL PROBLEM

[Problem(s) to be Solved by the Invention] As a result of this invention person's inquiring wholeheartedly and repeat examination in view of the various troubles of the Fe-Cr-aluminum system alloy in the former explained above, even it used this invention in the elevated temperature for a long time, it does not have fear of sagging generating by creep deformation, and developed the Fe-Cr-aluminum system powder alloy suitable as heater material and a high-temperature-service member.

[Translation done.]

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MEANS

[Means for Solving the Problem] The Fe-Cr-aluminum system powder alloy concerning this invention Cr 20 - 35wt% aluminum 4 - 12wt%, oxygen Less than [0.10wt%], Nitrogen Contain 0.05 - 0.20wt% and the Fe-Cr-aluminum system powder alloy characterized by the bird clapper from a remainder unescapable impurity and Fe is considered a the 1st invention. Cr 20 - 35wt%, aluminum 4 - 12wt%, oxygen Less than [0.10wt%], Nitrogen 0.05 - 0.20wt% is contained. further Y, Hf, Sc, In total one or more sorts chosen from rare earth elements More than 0.001wt% Contain below a solid-solution limit (less than [0.1wt%]), and the Fe-Cr-aluminum system powder alloy characterized by th bird clapper from a remainder unescapable impurity and Fe is considered as the 2nd invention. Cr 20 - 35wt%, aluminum 4-12wt% oxygen Less than [0.10wt%], Nitrogen 0.05 - 0.20wt% is contained. further Y, Hf, Sc, Less tha [1wt%] and more than 0.1wt% are contained for one or more sorts chosen from rare earth elements in total. The Fe-Cr-aluminum system powder alloy characterized by the bird clapper from a remainder unescapable impurity and Fe i considered as the 3rd invention. Cr 20 - 35wt%, aluminum 4-12wt% oxygen Less than [0.10wt%], Nitrogen 0.05 - 0.20wt% is contained. further Zr, Nb, Contain less than [1wt%] for one or more sorts chosen from Ti in total, and th Fe-Cr-aluminum system powder alloy characterized by the bird clapper from a remainder unescapable impurity and is considered as the 4th invention. Cr 20 - 35wt%, aluminum 4-12wt% oxygen Less than [0.10wt%], Nitrogen 0.05 0.20wt% is contained. further Y, Hf, Sc, Less than [1wt%] and more than 0.1wt% are contained for one or more sor chosen from rare earth elements in total. Moreover, less than [1wt%] is contained for one or more sorts chosen from Zr, Nb, and Ti in total. The Fe-Cr-aluminum system powder alloy characterized by the bird clapper from a remainde unescapable impurity and Fe is considered as the 5th invention. Cr 20 - 35wt%, aluminum 4 - 12wt%, oxygen Less than [0.10wt%], Nitrogen 0.05 - 0.20wt% is contained. further Y, Hf, Sc, In total one or more sorts chosen from rar earth elements More than 0.001wt% Less than [1wt%] is contained in the one or more sort sum total which contain below the solid-solution limit (less than [0.1wt%]), and was chosen from Zr, Nb, and Ti, and it consists of six invention which considers the Fe-Cr-aluminum system powder alloy characterized by the bird clapper from a remainder unescapable impurity and Fe as the 6th invention.
[0008] The Fe-Cr-aluminum system powder alloy concerning this invention is explained to a detail below. First, the component and component rate of an Fe-Cr-aluminum system powder alloy concerning this invention are explained.
[0009] Cr is an element which gives oxidation resistance, and if less than [20wt%] is [a content] inadequate as for oxidation resistance and it exceeds 35wt% less than, it forms and stiffens a sigma phase. Therefore, Cr content may b 20 - 35wt%.
[0010] aluminum is an element which gives oxidation resistance like Cr, and less than [4wt%], if a content runs sho of oxidation resistance and exceeds 12wt%, it stiffens it. Therefore, aluminum content may be 4 - 12wt%.
[0011] Processability will become bad if an oxygen content exceeds 0.10wt(s)%. Therefore, an oxygen content is ma into less than [0.10wt%].
[0012] If sagging-proof nature gets worse less than [0.05wt%] and a nitrogen content exceeds 0.20wt%, processabi will deteriorate. Therefore, a nitrogen content may be 0.05 - 0.20wt%.
[0013] a heater and a high temperature service -- in order to enable it to use a member etc. at an elevated temperature for a long time, and it is important to suppress the generation rate of the oxide film of aluminum and Cr and to suppr the generation rate of an oxide film, it is good to raise the peeling resistance of an oxide film, for that, it is the sum to about one or more sorts chosen from Y, Hf, Sc, and rare earth elements, such as Ce, La, Pr, and Nd, and it is good to make a content into less than [1wt%]
[0014] Moreover, Y, Hf, Sc, Ce, La, Pr, Nd, etc. make high the degree which an oxide film sticks on an alloy, and ha the effect which prevents an oxide film's exfoliating and the amount of oxides increasing. However, since toughness

will deteriorate and sagging will become large if a content exceeds 1wt% also for one sort or the sum total, one or m sorts of contents chosen from rare earth elements, such as Y, Hf, Sc, or Ce, La, Pr, Nd, are made into less than [1wt% in total.

[0015] Furthermore, since Y, Hf, Sc, and rare earth elements strengthen adhesion of the 2Oaluminum3 coat and alloy which are formed in the front face of an Fe-Cr-aluminum system alloy, although they are effective in improving life properties, such as oxidation resistance and oxide-skin adhesion A content cannot acquire oxidation resistance good less than [0.001wt%]. Moreover, if a content exceeds a solid-solution limit (0.1wt%), the crystallization object of a active element will come to appear, a secondary recrystallizing temperature becomes high, sagging-proof nature com to deteriorate conversely, and there is a problem for the use as which this property is required. Therefore, although th minimum of one or more sorts of contents chosen from Y, Hf, Sc, and rare earth elements carries out to more than 0.001wt% in total, for the use as which especially the above-mentioned sagging-proof nature is required, it is desirab to carry out to below a solid-solution limit (0.1wt%).

[0016] a heater and a high temperature service, in order to enable it to use a member etc. at an elevated temperature f a long time In order it is important to suppress the generation rate of the oxide film of aluminum and Cr and to suppr the generation rate of an oxide film It is good to raise the peeling resistance of an oxide film. for that It is what make content less than [1wt%] for one or more sorts chosen from Zr, Nb, and Ti in total. It is good to make one or more sorts chosen from these contain. Zr, Nb, by making high the degree which an oxide film sticks on an alloy, and havin the effect which prevents an oxide film's exfoliating and the amount of oxides increasing, if a content exceeds 1wt% also in one sort or the sum total, toughness will deteriorate, and sagging comes for Ti etc. to be large Therefore, one more sorts of contents chosen from Zr, Nb, and Ti may be less than [1wt%] in total.

[0017] In the Fe-Cr-aluminum system powder alloy concerning this invention, AlN was formed by aluminum and N majority of these AlN(s) are distributed minutely uniformly, and the temperature of 1100-1200 degrees C has preven the grain growth. Moreover, if the Fe-Cr-aluminum system powder alloy concerning this invention is made to contai which element of Zr, Nb, and Ti, it will be distributed still more minutely uniformly and a grain growth will be prevented from the AlN particle which ZrN, NbN, TiN, etc. explained above by Zr, Nb, Ti, and N by the complex grain-growth prevention effect of the above-mentioned AlN particle and which particle of ZrN, NbN, and TiN also i the temperature of nearly 1200 degrees C. since it is the 1200-degree C neighborhood and an elevated temperature, t crystal-growth force is large, it becomes a macro-crystal grain, therefore a creep property is improved, and generatin of sagging becomes and although the grain-growth prevention effect decreases and secondary recrystallization happe by coalesce or dissolution of AlN, ZrN, NbN, TiN, etc. in this temperature neighborhood, there is less at the time of use [little]

[0018] On the other hand, in the Fe-Cr-aluminum system alloy by the conventional ingoting method, since there is n particle which prevents a grain growth, although a gently-sloping grain growth starts gradually in connection with a temperature rise, a macro-crystal grain is not produced after the recrystallization in the temperature of 600-700 degre C.

[0019]

[The example of fruit **] The example of the Fe-Cr-aluminum system powder alloy concerning this invention is explained.

[0020]

[Example of fruit ** 1] The alloy-powder end of the component and component rate which are shown in Table 1 wa manufactured by the atomizing method. In addition, No.1-No.3 (comparison material) were manufactured by the arg atomizing method, and No.4-No.13 (this invention) were manufactured by the nitrogen gas atomizing method. No.14 are based on the ingoting method used for comparison, and are JIS FCH1 steel.

[0021] Bore 70phi and the container made from mild steel with a length of 150mm were filled up with these powder No.1-No.13, and they were sealed after after [vacuum heating] deaeration. Then, in the temperature of 1100 degree C, it extruded to the bar of 30 phixL after 2-hour heating, and the powder material of true density (100% density) wa created.

[0022] From No.14 of 13 kinds of this powder material, and the ingot material for comparison, it considered as the diameter of 8mm by the wire drawing after hot rolling, and the 8phix200mm sagging test piece was created. The sagging examination installed the test piece 2 on the fixture 1 whose span distance as shown in drawing 1 is 140mm, heated it in temperature of 1500 degrees C for 5 hours, and was performed by measuring the amount of displacemen A center sections of the test piece 2. The test result is shown in Table 2. It turns out that the Fe-Cr-aluminum system

powder alloy which requires N content for a 0.05 - 0.20wt% this invention from this table 2 is extremely excellent in sagging-proof nature. moreover, comparison material -- No.1-No.3 have a sagging ** case according to manufacture conditions and a test condition still more greatly than the ingot material of No.14, and they are not practical

[0023] Although the microphotography of the crystalline structure of the cross section of the sagging examination w rod after 5-hour heating is shown in the temperature of 1500 degrees C at drawing 2 and drawing 3 , the comparison material of No.1 of drawing 2 is an organization where the sagging property has deteriorated, and a macro-crystal gr is not accepted. On the other hand, a macro-crystal grain is accepted in No.4 of the Fe-Cr-aluminum system powder alloy concerning this invention of drawing 3 , therefore creep resistance improves, and the property which was excellent in the sagging examination is shown.

[0024] Next, in order to investigate the life property of the material shown in Table 1, heating wire of JIS C2524 (19 and life test of a band were performed. For 2 minutes, this examination repeats operation of the pause during energization and 2 minutes, performs a test piece 2 so that the test piece 2 used as the 0.5phix200mm wire rod may b fixed to the supported-end child 4 at U typeface as shown in drawing 4 , and the position of the pars basilaris ossis occipitalis 3 of the test piece 2 of U typeface may become the temperature which is 1300 degrees C, and it asks for th number of times of energization when a test piece 2 is disconnected.

[0025] 100 times or more of the number of times of energization is required for the convention life value of the charg of an Fe-Cr-aluminum system powder alloy which carries out a deer and a heater life value requires for this inventio according to the alloyed wire for electric heat and band of JIS C2520 (1986). The result of life test is shown in Table with the sagging test result.

[0026] As shown in Table 2, they are less than [oxygen 0.10wt%] and nitrogen 0.05-0.20. Into a wt% Fe-Cr-aluminum system powder alloy One or more sorts of sum total contents of rare earth elements, such as Zr, Nb, Ti, Y Hf, Sc, and Ce, La, Pr, Nd, are less than [1wt%]. It turns out that the life value of heater material which consists of charge of an Fe-Cr-aluminum system powder alloy concerning this invention is improving more sharply than JIS FC of ingot material, and it also doubles and has long lasting nature with hot sagging-proof nature.

[0027]

[Table 1]

[0028]
[Table 2]

No	化学成分 (wt%)														
	C	Cr	Al	Zr	Nb	Ti	Y	Hf	Ce	La	Pr	Nd	O	N	Fe
1	0.01	23	5.1	−	−	−	−	−	−	−	−	−	0.015	0.009	残部
2	0.01	27	5.3	−	−	−	−	−	−	−	−	−	0.012	0.011	〃
3	0.09	20	5.2	−	−	−	−	−	−	−	−	−	0.015	0.013	〃
4	0.01	23	5.2	−	−	−	−	−	−	−	−	−	0.015	0.060	〃
5	0.01	27	5.4	−	−	−	−	−	−	−	−	−	0.010	0.080	〃
6	0.07	21	10.2	−	−	−	−	−	−	−	−	−	0.013	0.190	〃
7	0.01	23	5.0	0.2	0.1	−	−	−	−	−	−	−	0.011	0.075	〃
8	0.03	21	5.3	0.3	0.1	0.1	−	−	−	−	−	−	0.030	0.070	〃
9	0.02	23	5.9	0.2	−	−	0.7	−	−	−	−	−	0.010	0.105	〃
10	0.01	27	5.1	0.1	−	−	−	0.4	−	−	−	−	0.014	0.083	〃
11	0.01	23	7.0	−	−	−	−	−	0.4	0.2	0.1	0.1	0.070	0.140	〃
12	0.01	23	5.7	0.3	−	0.2	0.1	−	0.2	−	−	−	0.035	0.071	〃
13	0.02	20	5.2	0.2	−	0.1	−	0.2	0.1	0.1	−	−	0.047	0.095	〃
14	0.02	23	5.4	−	−	−	−	−	−	−	−	−	0.006	0.020	〃

No.1～No.3・・・比較材，No.4～No.13・・・本発明，No.14・・・溶製材

No	高温ダレ量 (mm)	寿命値 (回)
1	32.5	218
2	28.1	242
3	29.3	210
4	2.5	230
5	2.0	283
6	2.5	329
7	0.4	324
8	3.3	390
9	7.2	513
10	6.0	472
11	6.5	501
12	8.0	522
13	8.0	487
14	31.5	223

No.1～No.3・・・比較材

No.4～No.13・・本発明

No.14・・・溶製材

[0029]
[Example of fruit ** 2] this example -- setting -- Y, Hf, Sc, and rare earth elements -- 0.001 - 0.1wt% -- a predominance over the sagging-proof nature in the case of containing is explained below The alloy-powder end of th component and component rate which are shown in Table 3 was manufactured by the atomizing method. In addition the alloy which corresponds to a claim 1 by the case where No.15-No.18 (this invention material 1) do not contain Y Hf, Sc, and rare earth elements, and No.19-No.22 (this invention material 2) are alloys which correspond to a claim 3 by the case where it contains more than a solid-solution limit (0.1wt%), and explain Y, Hf, Sc, and rare earth elemen for comparison. No.23-No.28 (this invention material 3) -- Y, Hf, Sc, and rare earth elements -- more than 0.001wt% the case of the alloy which contains and corresponds to a claim 2 by the below solid-solution limit (0.1wt%) case is shown [0030] Bore 70phi and the container made from mild steel with a length of 150mm were filled up with these powder, and it was sealed after after [vacuum heating] deaeration. Then, in the temperature of 1100 degrees C, it extruded to the bar of 30 phixL after 2-hour heating, and the powder material of true density (100% density) was created. 14 kinds of this powder material was made into the diameter of 8mm by the wire drawing after hot rolling, a the 8phix200mm sagging test piece was created.
[0031] The sagging examination installed the test piece 2 on the fixture 1 whose span distance as shown in drawing 1 140mm, heated it in temperature of 1500 degrees C for 5 hours, and was performed by measuring the amount of displacement of A center sections of the test piece 2. The test result is shown in Table 4.
[0032] Next, in order to investigate the life property of the material shown in Table 1, heating wire of JIS C2524 (19 and life test of a band were performed. For 2 minutes, this examination repeats operation of the pause during energization and 2 minutes, performs a test piece 2 so that the test piece 2 used as the 0.5phix200mm wire rod may b fixed to the supported-end child 4 at U typeface as shown in drawing 4 , and the position of the pars basilaris ossis occipitalis 3 of the test piece 2 of U typeface may become the temperature which is 1300 degrees C, and it asks for th number of times of energization when a test piece 2 is disconnected.
[0033] 100 times or more of the number of times of energization is required for the convention life value of the charg of an Fe-Cr-aluminum system powder alloy which carries out a deer and a heater life value requires for this inventio according to the alloyed wire for electric heat and band of JIS C2520 (1986). The result of life test is shown in Table

with the sagging test result.
[0034] Although sagging-proof nature is good in the powder heater material (this invention material 1) which does n contain one or more sorts chosen from rare earth elements, such as Y, Hf, Sc, and Ce, La, Pr, Nd, as shown in Table and 4, it turns out that a life value is low. moreover, one or more sorts chosen from rare earth elements, such as Y, H Sc, and Ce, La, Pr, Nd, -- the sum total -- 0.3 - 0.8wt% -- in the heater material (this invention material 2) to contain, although the life property is good, it turns out that sagging-proof nature has deteriorated compared with the comparis material 1 And one or more sorts chosen from rare earth elements, such as this invention material 3 applicable to a claim 3, i.e., Y, Hf, and Sc, and Ce, La, Pr, Nd, are known by that both the heater material that is below solid-solutio limits (0.1wt%) is excellent in sagging-proof nature and a life property in total more than at 0.001wt%.
[0035]
[Table 3]

[0036]
[Table 4]

No	化学成分 (wt%)														
	C	Cr	Al	Zr	Nb	Ti	Y	Hf	Ce	La	Pr	Nd	O	N	Fe
15	0.01	23	5.2	−	−	−	−	−	−	−	−	−	0.015	0.060	残部
16	0.01	27	5.4	−	−	−	−	−	−	−	−	−	0.010	0.080	〃
17	0.01	23	5.0	0.2	0.1	−	−	−	−	−	−	−	0.011	0.075	〃
18	0.03	21	5.3	0.3	0.1	0.1	−	−	−	−	−	−	0.030	0.070	〃
19	0.02	23	5.9	0.2	−	−	0.7	−	−	−	−	−	0.010	0.105	〃
20	0.01	27	5.1	0.1	−	−	−	0.4	−	−	−	−	0.014	0.083	〃
21	0.01	23	7.0	−	−	−	−	−	0.4	0.2	0.1	0.1	0.070	0.140	〃
22	0.01	23	5.7	0.3	−	0.2	0.1	−	0.2	−	−	−	0.035	0.071	〃
23	0.02	23	5.3	0.2	−	−	0.01	−	−	−	−	−	0.020	0.090	〃
24	0.01	27	5.8	0.2	−	−	0.005	−	−	−	−	−	0.025	0.085	〃
25	0.03	23	6.0	0.2	0.1	0.1	0.002	−	0.002	−	−	−	0.015	0.120	〃
26	0.01	27	5.2	−	−	0.1	−	0.05	−	−	−	−	0.020	0.105	〃
27	0.02	23	7.0	0.2	−	−	−	0.02	0.02	−	−	−	0.010	0.095	〃
28	0.02	23	5.4	0.3	−	−	−	−	0.02	0.02	0.01	−	0.015	0.088	〃

No.15～No.18（本発明材1），No.19～No.22（本発明材2），
No.23～No.28（本発明材3）

No	高温ダレ量 (mm)	寿命値 (回)
15	2.5	230
16	2.0	283
17	0.4	324
18	3.3	390
19	7.2	513
20	6.0	472
21	6.5	501
22	8.0	522
23	2.2	515
24	2.8	490
25	3.2	480
26	1.5	520
27	2.6	462
28	1.4	494

No.15～No.18（本発明材1）

No.19～No.22（本発明材2）

No.23～No.28（本発明材3）

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DESCRIPTION OF DRAWINGS

[Brief Description of the Drawings]
[Drawing 1] It is a schematic diagram for performing a sagging examination.
[Drawing 2] It is the microphotography in which the crystalline structure of the cross section of the sagging examination wire rod of comparison material is shown.
[Drawing 3] It is the microphotography in which the crystalline structure of the cross section of the examination wire rod of the Fe-Cr-aluminum system powder alloy (No.4) concerning this invention is shown.
[Drawing 4] It is a schematic diagram for investigating the life property of an examination wire rod.
[Description of Notations]
1 ... Fixture
2 ... Test piece
3 ... The bottom thermometry section of a test piece
4 ... Supported-end child

[Translation done.]

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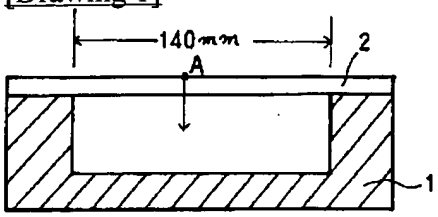
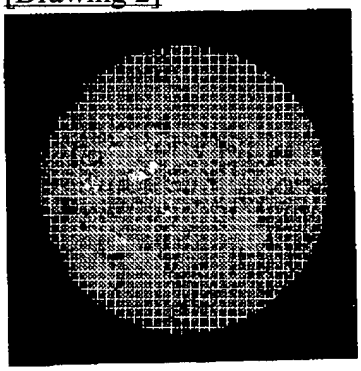
DRAWINGS

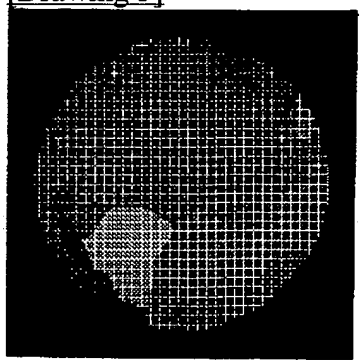
[Drawing 1]



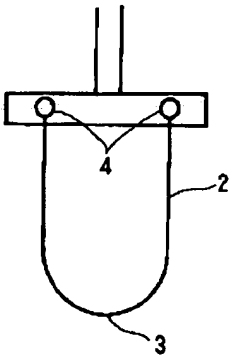
[Drawing 2]



[Drawing 3]



[Drawing 4]



[Translation done.]